 184

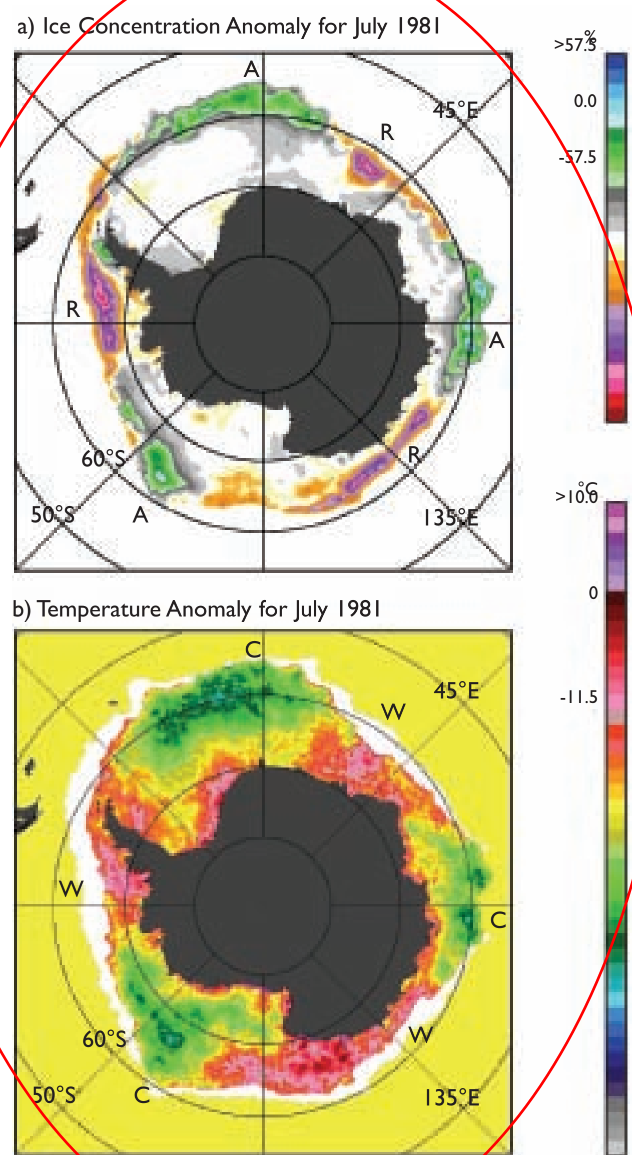
in winds that drive the ice in large scale clockwise circulation patterns. Loose ice pack can reach speeds that transport the ice several tens of kilometers each day, as confirmed by the ice-bound drift of the Endurance.

Figure 2 indicates the average drift speed and direction detected using satellite data. The pattern reveals the large clockwise, cyclonic circulations or 'gyres' known now to be characteristic of both the Weddell and Ross Seas. Each gyre carries ice floes towards the open seas at speeds of up to 65 kilometers a day, with average daily values closer to 10 kilometers a day (indicated by red). Figure 2 shows the satellite measured average winter drift speeds and drift tracks for the three months from July to September in 1996.

During winter, temperatures typically range from -15° C to -35° C over the coastal sea-ice pack. Coastal areas, and especially the Antarctic Peninsula (extending northward beyond the Polar Circle) experience a maritime influence, with generally higher temperatures and summer mean temperatures around 0° C. On the coast during the southern hemisphere summer, temperatures oscillate around 0° C with peaks of 15° in the warmest spots. This contrasts lower Antarctic interior temperatures range from -15° to -42°C.

Using satellite data, year to year variations in sea ice extent and surface temperature have been shown to be significant. These changes are now known to be connected with phenomena known as the Antarctic Circumpolar Wave (ACW) and the El Nino Southern Oscillation (SO).

The Antarctic Circumpolar Wave (ACW) comprises a coupled atmosphere-ice-ocean system that roams in a clockwise direction around the entire continent over a period of about 8 years. A visual "snap-shot" representation of the impact of such a system is shown in Figure 3 in the July 1981 anomaly maps (in austral winter) for both ice concentration and surface ice temperature. Sea ice around the northern margin of the winter ice pack displays alternate patterns of advance (A) and retreat (R) that are coherent with patterns of warming (W) and cooling (C) in Figures 3a and 3b, respectively.



Antarctic sea ice concentration and extent maps have been derived from data acquired continuously using satellite passive microwave instruments since 1979. The image in (a) shows the difference between the July 1981 monthly average conditions and the 25 year average for July. This so-called anomaly map indicates the effect of the ACW, and is characterised by a regular pattern of sectors of ice edge advance (marked A) and retreat (marked R). Corresponding surface temperatures are derived from satellite thermal infrared data. The image in (b) shows a similar surface temperature annomaly map for July 1981 that indicates the correspondence of relatively cold surface temperatures (marked C) with ice edge advance, and relatively warm air temperatures (marked W) in locations of ice edge retreat.

The imprint of the ACW is most readily visible in the ice pack and is not as apparent in the open ocean or on the continent. The white area around the ice pack in the surface temperature map (in Figure 3b) indicates the maximum ice extent during the period 1979-1999. It is shown that the white area is broadest in sectors that are warmer than normal, indicating the strong impact of the ACW on the ice extent. It is interesting to note that the ACW causes ice concentration anomalies that are fairly localised at the ice edge, while the temperature anomalies extend further south. This is largely because the ice cover to the south is generally thicker and more consolidated. Ice-edge advance occurs when cold southerly winds blow off the continent. The flow of cold air drives the ice pack to the north and allows ice-growth favourable conditions to persist. Conversely, in areas of ice retreat surface temperatures are warm because of northerly winds that carry warmer air masses from lower latitudes. Northerly winds cause ice edge melting and poleward retreat of the pack. Atmospheric pressure and wind are thus also essential components of the ACW. Though they are not shown explicitly here, their effects clearly also help to reinforce the patterns in Figure 3.